Cyclic Technologies

September 22, 2008

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

**Re: ENSC 440 Project Proposal for a Bicycle Anti-lock Braking System**

Dear Dr. Rawicz:

The attached document, Proposal for a Bicycle Anti-lock Braking System, provides a general overview of Cyclic Technologies' proposed project for ENSC 440. The project goal is to develop an ABS system for bicycles that would enable riders to maintain more control and stop faster during hard braking events. We believe that this would improve rider safety, especially in poor weather conditions, and could potentially save cyclists from serious injury or even death by enabling them to maintain better control of their bicycles and avoid accidents.

This document provides an overview of Cyclic Technologies ABS system and outlines design considerations and the reasoning behind our design choices. Discussions on sources of funding, budgeting outline, project timelines, and company dynamics and composition are also included.

Cyclic Technologies consists of five dedicated, resourceful, and enthusiastic engineering students: Zack Blair, Amir Tavakoli, Rahm Lavon, Datis Danesh, and Milad Gougani. Our team brings together people with different skill sets and experience, but all with the same goal: to create an ABS system for bicycles that will make bicycling safer and more enjoyable than ever before.

Thank you for considering our proposal. Should you require additional information or would like to meet us in person, please feel free to contact us at cyclic-tech@sfu.ca.

Sincerely,

*Amir Tavakoli*

Cyclic Technologies

Enclosure: *Proposal for a Bicycle Anti-lock System*

Cyclic Technologies

# Proposal

## Bicycle Anti-lock Braking System

**Submitted to:**

Dr. Andrew Rawicz – ENSC 440
Mike Sjoerdsma – ENSC 305
School of Engineering Science
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9/22/08


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# Executive Summary

Bicycling can be a very dangerous activity, largely because bicyclists have little to no protection relative to other vehicles on the road. In 2001, Transport Canada recorded 60 bicyclist fatalities and thousands of bicyclist injuries [6]. Governments have mandated safety equipment like helmets to protect cyclists in the event of an accident, but as any experienced bicyclist will tell you, keeping safe on a bike is largely about avoiding accidents in the first place. To meet this need for better bicycling safety, Cyclic Technologies is developing an antilock braking system (ABS) for bicycles that will help cyclists to avoid accidents by enabling them to stop faster and with more control.

ABS systems are included in most new cars, and are integral parts in many new motorcycles and trucks, but we were unable to find any company marketing a true ABS system for a bicycle. Yet, ABS systems have been proven to drastically improve control in panic situations, especially for two-wheeled vehicles like motorcycles [1]. Thus, we are confident that there is a genuine market need for such a product that Cyclic Technologies is well suited to meet.

Our target market consists of mostly performance bicycle enthusiasts – an affluent, performance-oriented, 20-30 year old demographic – which typically has considerable expendable income. Therefore, our primary goal in the design of our system will be to create a high-performance system with excellent reliability rather to minimize costs. Nevertheless, we expect the total cost of our system to be under $200, which is comparable to other performance bicycle accessories.

Our ABS system would consist of an electronic control unit (ECU), two wheel speed sensors (one for each wheel), and two brake actuators. Additionally, it would provide the rider with a digital speedometer and trip meter display and a plethora of configuration options to further improve their riding experience.

Hence, Cyclic Technologies' ABS System for bicycles meets a real need in the performance bicycle accessories market, and – being the first system of its kind to market for use on bicycles – is a breakthrough in bicycle brake systems.

 

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# 1. Introduction

On a rainy day, the average cyclist is at an extreme disadvantage compared to other vehicles where hard braking is required to avoid traffic or obstacles on the road. Ever since anti-lock braking systems (ABS) were introduced for aircraft in 1929, they have enabled people to stop more quickly and safely. In 1978, an ABS system was first utilized in the automobile industry in a completely electric four-wheel multi-channel ABS for trucks and cars developed by Bosch and Mercedes-Benz. In 1988, BMW realized the need to introduce ABS systems for motorcycles and became the world's first company to develop an electric/hydraulic ABS system for its motorcycles [1].

When a cyclist has to brake hard – to avoid an obstacle or another vehicle – they often risk skidding and flipping over, especially on wet or slippery surfaces. Even with mandatory safety equipment like helmets, many cyclists lose control of their bicycles when faced with the need to stop suddenly, sometimes leading to serious injuries or even death. It is our hope that many of these incidents can be avoided by using our ABS system for bicycles.

Today there are a number of products that mechanically balance the braking force between the front and rear wheels on a bicycle to avoid front-wheel lock-up; however, these products provide no feedback between the wheel speed and the brakes, and therefore are unable to detect and prevent wheel lock-up. Another shortcoming of current braking systems is that they are typically difficult to customize for particular cyclist preferences or road conditions. Cyclic Technologies' ABS braking system overcomes these shortcomings by preventing wheel lock-up during hard braking and by providing the user with the ability to easily customize the braking system's performance using a menu-driven user interface on an LCD display.

# 2. System Overview

Cyclic Technologies ABS will be composed of an electronic control unit (ECU), two wheel speed sensors (one for each wheel), and two brake actuators as shown in Figure 1. The wheel speed sensors also double as induction generators, recharging the batteries inside the ECU which operates the system. Also included are two LCD displays that show a speedometer and an odometer, or an optional pressure sensor for the rear suspension.

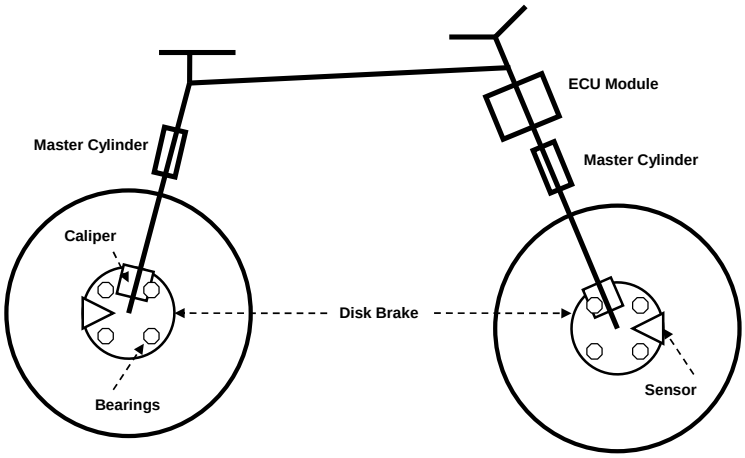



Figure 1: System Overview

A simple overview of the system operation is summarized in Figure 2.

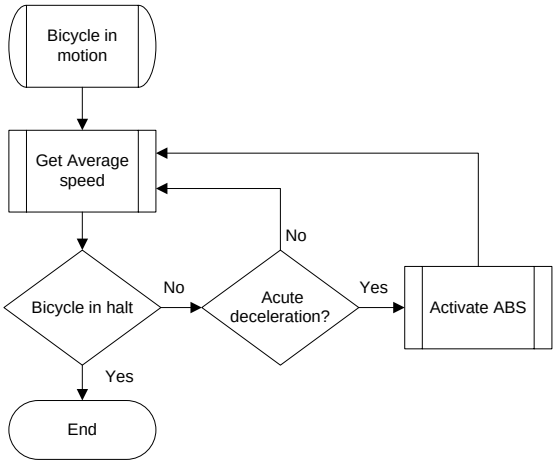



Figure 2: System Flowchart

When the bicycle is first put in motion, the induction generators and batteries inside the Electronic Control Unit (ECU) power the system and trigger it turn on. Wheel speed sensors read the pulses generated by the encoded generators, and send signals back to ECU module which continuously monitors wheel speeds for any abrupt deceleration or large disparity between the front and rear wheel speeds. When a brake is applied, pressure is increased in the calipers, forcing brake pads against the disks attached to each wheel, slowing the bicycle. If one or more wheels lose traction with the road surface, those wheel(s) will slow down quickly, indicating that they are close to locking. Hence, if a wheel's deceleration is abrupt and does not match the criteria stored in memory, the ABS system instantly responds by rapidly opening and closing valves to modulate the brake pressure applied by the rider. Figure 3 is a block diagram of the ABS activation procedure

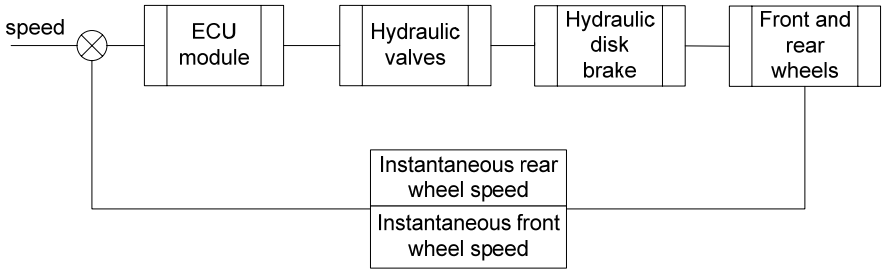



Figure 3: System Block Diagram

Therefore, ABS acts as a manual assist system that works when constant pressure is applied to the handlebar-mounted brake levers, preventing skidding and providing a more consistent braking distance for cyclists of all skill levels. In addition, the Cyclic Technologies ABS system allows the cyclists to monitor their speed, measure distance traveled, configure ABS parameters like reaction time, or even disable ABS through an interactive user interface. An optional feature to this system even prevents flipping the bicycle under extreme conditions.

# 3. Possible Design Solutions

Several proposed braking systems designed for bicycles and motorcycles exist in literature and industry. Some, like Cyclic Technologies' ABS System, work prevent the bicycle's wheels from locking during hard braking, thereby preventing the bicycle from skidding. Brake systems that are merely improvements of commercially available products are constantly being introduced. Some of these systems are discussed here.

## 3.1.Mechanically Actuated Mechanically Controlled Anti-lock Brake System

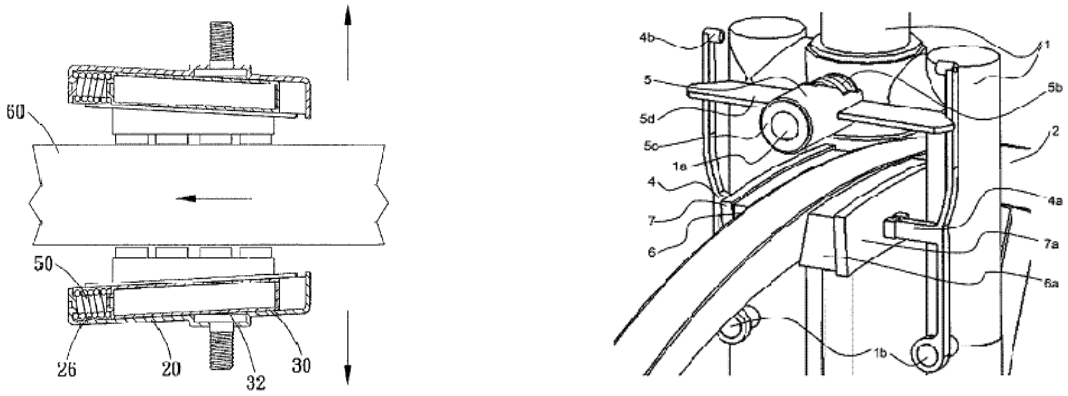



Figure 4: Mechanically actuated and controlled ABS system patent illustrations [3], [4]

These two previously procured, purely mechanical systems aim to release the brake in the event of a skid [3], [4]. Both systems use the linear pressure of the brake pads against the disc or wheel as a triggering force. Therefore, these systems effectively limit the maximum braking force that can be applied to the wheel. While this may decrease the risk of causing the wheel to skid in the first place, it is not a true antilock braking system because there is no way for the system to sense that the wheel has locked, and so on surfaces with reduced traction, the wheels are still bound to slip prematurely, and without the system's intervention.

## 3.2.BUDBRAKE™ ABS Modulator

The Budbrake ™ ABS modulator is a currently marketed system which balances the braking force applied mechanically to the front and rear wheels [2]. This system is primarily designed to aide novice riders, because they are not yet skilled to properly proportion the braking force between the front and rear wheels. This device adds the cable forces applied from each lever and distributes the total force while limiting the maximum braking force to the rear wheel, which usually slips first [2]. While this system helps inexperienced riders, it decreases the amount of control available for more experienced riders. It is also not a substitute for an antilock braking system, since it cannot disengage the brakes for a wheel that has lost traction.

## 3.3.Mechanically Actuated Electronically Controlled ABS

This system is comprised of a simple mechanical brake, much like that which the majority of bicycles are currently equipped with. The brake actuators are installed between the brake handle and the caliper and provide a pulsating slack in the brake cable line to momentarily

release the braking force in the event a wheel traction loss is detected by an electronic wheel speed sensor.

A suggestion from a fellow engineering student that has attempted this project before: "The really tricky bit is the actuator. We used a direct screw drive attached to a servo to slacken the cable. This worked very well. The problem came when tightening the cable. With a direct screw drive you had to keep pulling, which drained the battery very quickly. Some kind of ratcheting mechanism or better yet a hydraulic brake system with a check valve and pump would work better. You'll still have problems with battery life because the battery has to source power to do mechanical work, not just shuttle electrons around. You'll need something akin to a cordless drill battery, rather than a laptop battery, with the associated weight [5]." All the aforementioned problems are addressed in our proposed design solution.

# 4. Proposed Design Solution

Cyclic Technologies system is a hydraulically-actuated electronically-controlled anti-lock brake system. The system is comprised of hydraulically actuated brakes, such as those equipped on new high-end bicycles. The brake actuators are installed between the brake cylinder and the caliper and provide a pulsating pressure diversion from the caliper to the brake fluid reservoir to momentarily release the braking force in the event wheel traction loss is detected by an electronic wheel speed sensor.

The advantages of this system are numerous:

- **Low cost**- the components which the system adds to a current hydraulic braking system are few and economical. This improves the end-product's attractiveness to consumers.
- **Reliability**- The only moving components are the hydraulic solenoid valves, which have been proven in industry to be reliable in trials of 100,000 cycles or more
- **Speed**- The reaction of a hydraulic system is a fraction of the time for a mechanical actuator to deliver the force required to modulate the brake pressure.
- **Power**- Mechanical actuation systems consume large amounts of energy and would deplete the power source or tax the rider's efforts. This unit places very little, in any, noticeable burden on the rider.

- **Safety**- Motorcycles have, since the 1980's, been available with similar ABS systems. The industry is now rapidly evolving to widely introduce this technology as it has been shown to prevent accidents and save lives. This product is designed to bring the same benefits to bicycle riders.
- **Enhanced Features**- Our system can display instantaneous speed and distance travelled, and can allow the user to configure various ABS parameters or disable the ABS system via a menu-driven user interface.

Considering the tight time frame of less than 13 weeks, and limited resources available, we plan to make a working prototype of ABS on a hydraulic brake equipped bicycle. Although ambitious, we think our system can save lives and provide riders with a more enjoyable biking experience than ever before.

A further enhancement of the Cyclic Technologies ABS system for bicycles to provide even more safety for adventurous cyclists would include a rear suspension pressure sensor to prevent the bicycle from flipping over its handlebars in the event of excessive front wheel braking; if the brakes are applied on a downhill slope, or with excessive forces and the bicycle is on the verge flipping, the rear suspension pressure sensor will detect the low pressure on the rear wheel and signal the ECU to momentarily disengage the front brakes, preventing the bike from flipping.

The Cyclic Technologies Anti-lock Braking System will open a new chapter in bicycle development history, and may find additional applications to wheelchairs or even motorized mobility scooters.

# 5. Sources of Information

Cyclic Technologies is dedicated to extensive research and development to ensure the Cyclic Technologies ABS system is both safe and enjoyable for consumers. Invaluable resources for research include the US patent office, various textbooks on control systems, electronics, digital circuits, actuators and sensors.

In addition, the SFU faculty member will be a valuable resource to our team. We will also consult with previous graduate/undergraduate engineering students that have been involved in similar projects. Cyclic Technologies will not hesitate to seek help from knowledgeable individuals to improve its system designs.

Last but not least, the most important source of information for Cyclic Technologies systems will be our engineering team with its diverse and unique background.

# 6. Budget

Table 1 shows a detailed estimate of the total project materials cost for Cyclic Technologies' ABS system.

Table 1: Tentative Budget

| Item | Quantity | Price |
|---|---|---|
| Enclosure | 1 | $5.00 |
| Circuit Board | 1 | $2.00 |
| Microcontroller | 1 | $5.00 |
| Crystal | 1 | $1.00 |
| LCD Display | 1 | $15.00 |
| LCD Enclosure | 1 | $5.00 |
| Resistors, Caps, etc | 1 | $1.00 |
| Tactile Switches | 3 | $1.00 |
| Power switch | 1 | $1.50 |
| Speed Sensor / Generator | 2 | $30.00 |
| Solenoid / Actuator | 2 | $20.00 |
| Rechargable batteries | 2 | $10.00 |
| Battery holder | 1 | $1.00 |
| Misc ICs | 1 | $15.00 |
| | | |
| **Total** | | **$174.50** |

The estimate above does not include the cost of a bicycle that will be used for development, because the bicycle is not expendable and is not part of the finished product.

# 7. Funding

Cyclic Systems will fund the development and production of the bicycle ABS system primarily with its own existing capital. Additionally, up to $50 of shop supplies and electrical components will be acquired from SFU's Engineering Science lab at no additional cost to Cyclic Systems.

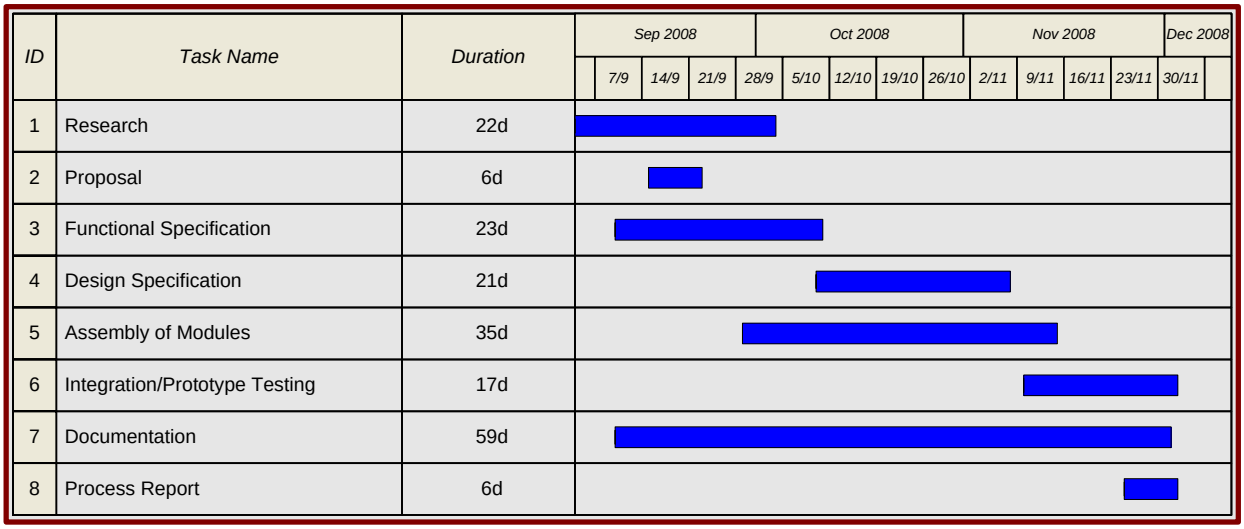
 

# 8. Timeline

The table below shows the Gantt chart of the expected time to be spent on the tasks involved the project. Figure 5 shows the corresponding expected completion dates for the various tasks and documentation of our proposed project.

**Table 2: Gantt Chart**

| ID | Task Name | Duration |
|---|---|---|
| 1 | Research | 22d |
| 2 | Proposal | 6d |
| 3 | Functional Specification | 23d |
| 4 | Design Specification | 21d |
| 5 | Assembly of Modules | 35d |
| 6 | Integration/Prototype Testing | 17d |
| 7 | Documentation | 59d |
| 8 | Process Report | 6d |



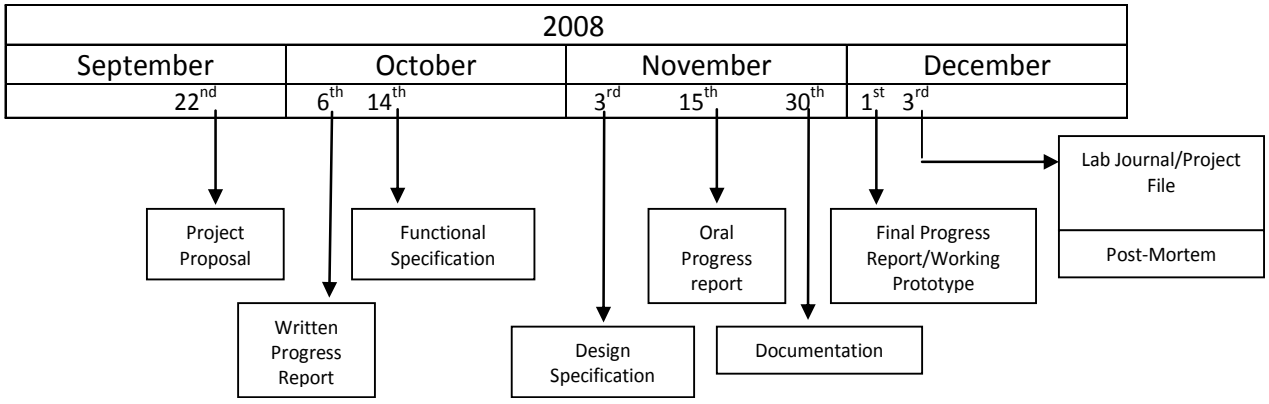
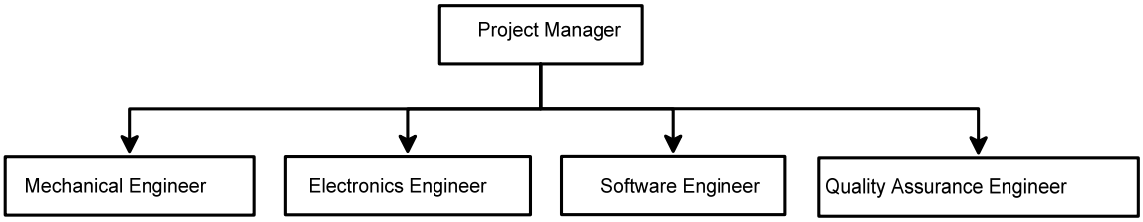




**Figure 5: Milestone Chart**

# 9. Team Organization

To encourage communication and collaboration, our organization has chosen a relatively flat, rather than hierarchical structure. Each team member is given primary responsibility for one aspect of the project, thereby organizing our team around work functions rather than bureaucratic hierarchy. Thus, each team member is directly involved in the decision-making process and is therefore able to contribute to the direction of the organization. This organization enables Cyclic Technologies to be more responsive to change, and supports our collaborative and creative corporate culture.



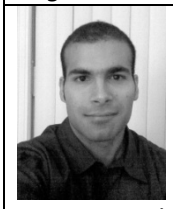
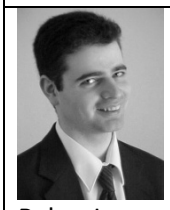

Our team includes a Project Manager to keep track of our team's progress and inform the team if it begins to fall behind schedule. Although all team members share responsibility for managing themselves and the team as a whole, the project manager's primary duty is keep the team on schedule, and to help procure resources for development and manufacturing.

Our Mechanical Engineer is primarily responsible for designing the mechanical aspects of our project, which primarily consist of the brake actuator, and the mounting systems for the ECU and sensors; our Electronics Engineering is responsible for designing the ECU control board and the interface logic for the sensors; our Software Engineer is responsible for designing the real-time control system software for our ECU unit; finally, our Quality Assurance Engineer is responsible for testing the usability, reliability, and safety of our system throughout our development process.

# 10. Company Profile

The Cyclic Technologies team is composed of a group of five talented engineering students from diverse backgrounds.

| | |
|---|---|
|  <br>Milad Gougani<br>*Project Manager* | Milad Gougani is a fifth year Systems Engineering student at Simon Fraser University's School of Engineering Science. Milad has extensive knowledge and experience in poject management, electronics hardware and systems development acquired from involvement with Honeywell's advanced process and control systems. In addition, his enthusiasm, good organizational and strong leadership skills will help him to make a positive contribution to the team. |
|  <br>Zachary Blair<br>*Software Engineer* | Zachary Blair is a 5th year Engineering Science student who has experience in electronic design using microcontrollers and in software engineering. His expertise will be an asset for the development of the electronic control unit (ECU) that is critical to the hard real-time performance of the ABS system. |
|  <br>Amir Tavakoli<br>*Quality Assurance Engineer* | Amir Tavakoli is a fifth year student at Simon Fraser university school of engineering science. He has experience is electronic system design and real-time operating systems. He is well informed in today's electronic industry standards and innovations and currently provides building engineering consulting services at Stantec Consulting Ltd. Also, he is mountain biking enthusiast. |
|  <br>Datis Danesh<br>*Electronics Engineer* | Datis Danesh is a fifth year Systems Engineering student at Simon Fraser University. He has circuit design and implementation experience gained from doing numerous labs in various electric circuits and system courses. In addition to these skills, he is also organized and can communicate and work well in teams. |
|  <br>Rahm Lavon<br>*Mechanical Engineer* | Rahm Lavon is a fifth year Electronics and Systems Engineering student at Simon Fraser University. He has extensive experience in mechanics, electro-mechanics, electronics, power circuitry and integration. He worked in industry at Exegin Technologies, Inc., designing a test platform and firmware stack for wireless Zigbee, IEEE 802.15.4. He also successfully designed and implemented a hardware platform for automotive multi-axis, wheel dynamics control |

# 11. Conclusion

Cyclic Technologies will be designing an antilock braking system (ABS) for a bicycle to enable riders to maintain control and stop faster during a hard braking event like those included in many new motorcycles and trucks. Hence, Cyclic Technologies' ABS System for bicycles provides cyclists with additional safety and performance over conventional braking systems, in addition to a speedometer and odometer display.

Our product is projected to cost less than $200, not including the bicycle. This is comparable to other high-end bicycle accessories.

# 12. References

[1] "Anti-lock Braking System" in *Wikipedia*, History, Sept. 18, 2008. [Online]. Available: http://en.wikipedia.org/wiki/Anti-lock_braking_system [Accessed: Sept. 21, 2008].

[2] *ABS Modulator*, budbrake.com, Product, 2005. [Online]. Available: http://www.budbrake.com [Accessed Sept. 21, 2008].

[3] Huang, Tan-cheng (Taichung, TW), "Anti-lock brake system for a bicycle,"U.S. Patent 6,786,308, Mar. 18, 2003.

[4] Peles, Zalman (Cfar Corazim, M.P., Corazim 12391, IL), "Antilock and antiskid mechanical brake system for vehicles and method thereof," U. S. Patent 7,299,901, Nov. 22, 2004

[5] D.Scothern, *Bicycle ABS*, Halfbakery.com, Sept. 9, 2006. [Online]. Available: http://www.halfbakery.com/idea/Bicycle_20ABS [Accessed: Sept. 21, 2008].

[6] Canada. Transport Canada, "Road Safety in Canada – 2001", *Transport Canada*. [Online]. Available: http://www.tc.gc.ca/roadsafety/tp/tp13951/2001/page7.htm [Accessed: Sept. 21, 2008]